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UPSTREAM PRODUCT MARKET REGULATIONS,

ICT, R&D AND PRODUCTIVITY

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Abstract

Our study aims to assess the actual importance of the two main channels via which upstream anti-competitive sector regulations are usually considered to impact productivity growth, i.e. by acting as a disincentive to business investments in R&D and in ICT. We estimate the specific impacts of these two channels and their shares in the total impact as opposed to alternative channels of investments in other forms of intangible capital that we cannot explicitly consider for lack of appropriate data such as improvements in skills, management and organization. To achieve this, we specify an extended production function explicitly relating productivity to R&D and ICT capital as well as to upstream regulations, and we specify two factor demand functions relating R&D and ICT capital to upstream regulations. These relations are estimated on the basis of an unbalanced panel of 15 OECD countries and 13 industries over the period 1987-2007. Confirming the results of previous similar studies, our estimates find that the impact of upstream regulations on total factor productivity can be sizeable, and they provide evidence that a good part of the total impact, though not a predominant one, is transmitted through investments in both R&D and ICT, and particularly the former.

Mots-clés : Productivité, Croissance, Régulations, Concurrence, Rattrapage, R&D, TIC

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I. Introduction

Competition is an important determinant of productivity growth. Much firm-level microeconomic research has supported the idea that competitive pressure enhances innovation and is a driver of productivity (among others, see Geroski, 1995a, 1995b; Nickell, 1996; Nickell *et al.*, 1997; Blundell *et al.*, 1999; Griffith *et al.*, 2002; Haskel *et al.*, 2007; Aghion *et al.*, 2004), especially for incumbent firms that are close to the technological frontier (Aghion *et al.*, 2005; Aghion *et al.*, 2006). Reinforcing evidence has also been found in investigations at a macroeconomic level, either using country panel data (Conway *et al.*, 2006; Aghion *et al.*, 2009) or country-industry panel data (Nicoletti and Scarpetta, 2003; Griffith *et al.*, 2010; Inklaar *et al.*, 2008; Buccirossi *et al.*, 2009). Most of these empirical studies have provided within country-industry evidence of the link between competitive conditions and productivity enhancements. In other words, these studies investigate the direct influence of competitive conditions in industries on these industries themselves.

In contrast to these studies, our paper focuses on the cross-industry influence of product market anti-competitive regulations in non-manufacturing industries, called 'upstream" industries thereafter, on productivity in industries that are using intermediate inputs from these upstream industries, called "downstream" industries.[1] We distinguish six non-manufacturing industries, which are the upstream industries: energy, transport, communication, retail, banking and professional services. Regulations that protect rents in upstream industries can reduce incentives to implement efficiency improvements in downstream industries, since downstream industry firms will have to share the expected rents from such improvements with upstream industries.[2] Indeed, if firms in downstream industries have to negotiate the terms and conditions of their contracts with suppliers, part of the rents expected downstream from adopting best-practice techniques will be grabbed by intermediate input providers. This in turn will reduce incentives to improve efficiency and curb productivity in downstream industries, even if competition may be thriving there. Moreover, lack of competition in upstream industries can also generate barriers to entry that curb

[1] Note that the distinction between upstream and downstream industries is not a priori clear-cut, since upstream industries use intermediate inputs from other upstream industries. As will become clear in the implementation of our analysis the non-manufacturing upstream industries are kept in our study sample. We thus estimate the overall average influence of upstream product market regulations (that is precisely the average influence of regulations in each upstream industry on all industries excluding that upstream industry).

[2] A theoretical model of this mechanism is proposed in Bourlès *et al.* (2010, 2013) and in Barone and Cingano (2011).

competition in downstream industries as well, further reducing pressures to improve efficiency in these industries.[3] From these mechanisms, upstream industry anti-competitive regulations are more harmful for downstream industries when these upstream industries produce a large share of intermediate inputs versus predominantly supply final consumption. Anti-competitive regulations correspond here to restrictions in competition and firms' choices. Corresponding indicators are based on detailed information on laws, rules as well as market and industry settings in two main areas: state control (covering specific information on public ownership and public control of business activities) and barriers to entrepreneurship (covering specific information on legal barriers to entry, market structure and/or industry structure).

The cross-industry influence of product market regulations is a particularly important issue, since – mainly as a result of increasing international competition – downstream manufacturing industries have become more competitive in the last twenty years or so in most OECD countries, while product market regulations in service industries have to a large extent remained significant. For instance, many years of compulsory practice are often required to become a full member of professional services (accounting, legal, engineering and architecture) and then to have the right to provide all the task assigned these professions.[4]

Only very few studies have investigated the influence of upstream competition on the performances of downstream industries. Some of them are panel data analyses for one country at the industry level, such as Allegra *et al*. (2004) for Italy, or at the firm level, Forlani (2010) on France and Arnold *et al*. (2011) on the Czech Republic, and they all use specific indicators of upstream competition, as for example Lerner index or concentration index. Other studies like Faini *et al*. (2006), Bourlès *et al.* (2013) and Barone and Cingano (2011) rely on country-industry panel data analyses and on the OECD regulation indicators in upstream industries, as we do in this paper.

The goal of the present investigation is to obtain a clearer understanding of the economic impact by attempting to pinpoint the exact mechanisms through which upstream regulations affect downstream productivity growth. As generally agreed, we consider investments in R&D as being a vital channel of productivity growth and we try to determine its importance

[3] A formalization of such links between upstream competition and downstream productivity can be found in Bourlès *et al*. (2010) the working paper version of Bourlès *et al*. (2013) and in chapter 2 of Lopez (2011).

[4] For more regulation examples, please see the OECD indicators underlying data (www.oecd.org/economy/reform/indicatorsofproductmarketregulationhomepage.htm).

as precisely as possible. Likewise, we analyse investments in ICT since these are also deemed to be a key channel for improvements in competitiveness.[5] In order to implement this investigation, as explained in Section II, we consider a three equations model that is simple enough to be specified and estimated with the data available at country-industry level. We thus estimate a relation where the distance of a given country-industry multifactor productivity to the corresponding industry multifactor productivity in the USA (the USA is taken as the country of reference) depends not only on the upstream regulatory burden indicator, but also on the distance of country-industry R&D and ICT capital intensities to that in the USA. In parallel we estimate two factor demand relations, for R&D and ICT capital respectively, which both include the upstream regulation burden indicator. To assess the robustness and validity of our results, we consider different econometric specifications of our model.

Our investigation is conducted on a cleaned unbalanced country-industry panel dataset for fifteen OECD countries and thirteen manufacturing and market service industries over the twenty one years from 1987 to 2007. These thirteen industries cover a large part of the non-agricultural economy and leave aside only industries that are (almost) not investing in either ICT or R&D. Among these thirteen industries we also exclude five of them to estimate the R&D investment demand equation, since they almost do not invest in R&D.

We rely on the same basic upstream regulatory burden indicator as Bourlès *et al.* (2013), computed from OECD indicators of anti-competitive regulations on product markets in the six non-manufacturing industries which are the upstream industries.We explain our data and present a number of descriptive statistics in section III and Appendix A.

Section IV discusses our identification strategy, the estimation method focusing on the long-term estimates of our parameters of interest and their robustness. In particular we systematically compare the estimation results obtained in two econometric specifications: the first one provides optimistic or "upper bound" estimates, while the second provides pessimistic or "lower bound" estimates. We present our estimation results in Section V, and

[5] Investing in training, in skilled labor, in organization and management are also potentially important channels that we could not consider here for lack of data or good enough data at the country-industry level. It is likely that these channels are to some extent complementary to the ICT and R&D channels, and thus that the regulatory impact working through them may be partly taken into account in our estimates. Note also that although patents are not as good a predictor of innovation output as R&D investment, the numbers of country-industry patents would be a worthwhile indicator to consider in the future (see Aghion *et al.* 2013 and Franco, Pieri & Venturini 2013).

illustrate them by presenting in Section VI simulations of what would be the long term multifactor productivity gains if all countries were to adopt the observed best or lightest anti-competitive upstream regulations. These simulations confirm overall the results of previous analysis showing that upstream anti-competitive regulations can slow down multifactor productivity importantly. The total productivity impacts of upstream regulations are the highest for Italy and the Czech Republic, and the lowest for the United Kingdom and the USA. An important part of this impact on productivity is transmitted through the R&D and ICT channels. The indirect productivity impact for the R&D investment channel is generally higher than the one for ICT investment, but the direct productivity impact is also much higher than both of them, suggesting that the channels through which upstream regulations manifest themselves must be many and pervasive. In Section VII we conclude.

II. Econometric model specification

Anti-competitive regulations in upstream industries can reduce incentives to search for efficiency improvements in downstream industries, as part of the rents expected from such improvements will have to be shared with suppliers of the intermediate inputs that are necessary for downstream production. We test this conjecture via three simple equations: a productivity equation and two similar factor demand equations, respectively for R&D and ICT. Below we explain in some detail our choice of specifications for these equations.

Productivity equation

Our productivity equation is based on the assumption of a cointegrated long-term relationship linking the levels of (multi-factor) productivity between countries and industries, which includes our product market regulation variable of interest or regulatory burden indicator *REG*. The introduction of this last variable allows us to assess that part of the upstream regulations impact on value added that is not already taken into account explicitly by the production function (see below), such as investments in training, organization and management.

The productivity equation can be simply written as a relation between the industry productivity in a given country of reference $\bar{c}$ and all the other countries c. Although it is

convenient to interpret this relation as a catch-up relation where the country of reference $\bar{c}$ is considered as a leading country and the other countries c as follower countries, it is important to realize that such an interpretation can be misleading. The basic hypothesis, which we actually test in Section IV, is that of cointegration for the set of country-industry time series that are considered in the analysis. In fact as long as the equation includes controls for country, industry and year unobserved common factors, we checked that the choice of the country of reference does not practically affect our results. In this work, for the sake of simplicity we take the USA as the leading country $\bar{c}$.[6] We can thus write our long-term productivity relation as the following log linear regression equation:

$$\widetilde{mfp}_{ci,t} = cst + \widetilde{mfp}_{\bar{c}i,t} - \mu \, REG_{ci,t-1} + u_{ci,t} \quad (1)$$

The variables $\widetilde{mfp}_{ci,t}$ and $\widetilde{mfp}_{\bar{c}i,t}$ are respectively the multifactor productivity in logarithms for year t of industry i in country c and in the leading country $\bar{c}$ (the USA), where $t \in T, i \in I$, and $(c, \bar{c}) \in C$ with $c \neq \bar{c}$.

The variable $REG_{ci,t-1}$ is the regulatory burden indicator lagged one year for industry i in country c, and μ is a parameter of main interest measuring an average long-term "direct" impact of regulation on multifactor productivity, where direct means here that this impact does not operate through the channels of ICT and R&D investments as made explicit below.[7]

The term $u_{ci,t}$ stands for the error in the equation that can be specified in different ways. In a panel analysis such as ours, it is generally found appropriate to control for separate country, industry and year unobserved common factors or effects θ_c , θ_i and θ_t, in addition to an

[6] The USA is in fact leading for 85% of the country-industry-year observations of our panel. As just mentioned, our estimates remain practically unaffected if we choose the leading country-industry-year definition. Note more generally that when we include industry*year effects θ_{it} in the specifications of our productivity, R&D and ICT investments equations (see below), these effects will proxy for the evolution of productivity, R&D and ICT investments for the country-industry pairs taken as reference as long as the reference country for a given industry does not change over time. Hence our lower bound estimates based on specifications including such effects are strictly identical irrespective of the choice of the country-industry pairs of reference.

[7] Note that in equation (1) we impose that the coefficient of $\widetilde{mfp}_{\bar{c}i,t}$ is 1, implying that the difference between the multifactor productivity of the follower countries and the leader country is bounded in the long term for given common factors $\theta's$. This is a reasonable identification hypothesis generally made in the literature. As shown in Appendix tables B2.1 and B2.2, our results remain roughly the same if this hypothesis is relaxed; they are strictly identical if we include industry*year effects θ_{it} as in our lower bound specification. We have also considered a variant of equation (1) in which the regulatory burden indicator is included as the difference to its value for the country-industry of reference: $(REG_{ci,t-1} - REG_{\bar{c}i,t-1})$. This variant provides estimates that are strictly identical in the specification with industry*year effects θ_{it}, and very close without them.

idiosyncratic error term $\varepsilon_{ci,t}$. Here, for reasons of econometric identification which we discuss in Section IV, we privilege two specifications that also include interaction effects: either country*year effects θ_{ct} or both country*year effects $\theta_{ct}$and industry*year effects θ_{it}. As we shall explain, we can consider that the first of these specifications provides an upper bound estimate of the direct regulatory impact parameter μ, while the second one provides a lower bound estimate of μ.

The major novelty in our approach here with respect to previous similar studies is that we want to assess to what extent the effects on productivity of anti-competitive regulations (as measured by REG) work through the two channels of R&D and ICT investments or otherwise. To do so we have to modify in two ways the "conventional" measure of multifactor productivity previously used. We have to take into account explicitly the contribution on value added (*Y*) of ICT capital to productivity and, for that, to separate ICT capital (*D*) from the other forms of physical capital (*C*) in total capital (*CT*). We also have to take into account explicitly the contribution of R&D capital (*K*), which is ignored in the "conventional" measure of total capital (*CT*), since R&D is not yet integrated in official national accounts as an investment.[8] Precisely, using small letters for logarithms (i.e. $x \equiv Log\ X$), we have a conventional measures of multifactor productivity mfp and the appropriate measure $\widetilde{mfp}$ to be used in the present analysis that both take into account the labor (*L*) contribution, but differ in their capital factors' contributions:

$$mfp = y - \alpha(ct) - \beta l$$

while

$$\widetilde{mfp} = y - \alpha c - \beta l - \gamma d - \delta k$$

8 As explained in Section III, the explicit integration of R&D implies that we had to correct the measures of industry output and labor from respectively expensing out R&D intermediate consumption and double counting R&D personnel.

In order to estimate simultaneously the direct impact of the regulatory burden indicator and the ICT and R&D elasticities, we rewrite regression equation (1) to include explicitly ICT and R&D contributions as regression equation (2):

$$mfp_{ci,t} = cst + mfp_{\bar{c}i,t} + \gamma\left[\left(d_{ci,t} - l_{ci,t}\right) - \left(d_{\bar{c}i,t} - l_{\bar{c}i,t}\right)\right] + \delta\left[\left(k_{ci,t} - l_{ci,t}\right) - \left(k_{\bar{c}i,t} - l_{\bar{c}i,t}\right)\right] + (\lambda - 1)(l_{ci,t} - l_{\bar{c}i,t}) - \mu\, REG_{ci,t-1} + u_{ci,t}$$

With $mfp_{ci,t} = \left(y_{ci,t} - l_{ci,t}\right) - \tilde{\alpha}\left(c_{ci,t} - l_{ci,t}\right)$ a partial multifactor productivity, $\tilde{\alpha}$ the calibration of the non-ICT capital elasticity and $\lambda = \tilde{\alpha} + \beta + \gamma + \delta$ the return to scale.[9]

As trying to assess returns to scale on aggregate industry data such as ours does not really make sense, we prefer to impose constant return to scale $\lambda = 1$. In fact, as documented in Appendix B on robustness, when we do not impose constant returns to scale and rely on the first option, our results are practically unaffected with an estimated scale elasticity λ that negligibly differs from 1 (this difference is even not statistically significant for our preferred specification, see Table B1 column 2).

Finally, assuming constant returns to scale implies we can express (2) equivalently as:

$$mfp_gap_{ci,t} = cst + \gamma d_gap_{ci,t} + \delta k_gap_{ci,t} - \mu\, REG_{ci,t-1} + u_{ci,t} \qquad (3)$$

Where $x_gap_{ci,t} = \left[\left(x_{ci,t} - l_{ci,t}\right) - \left(x_{\bar{c}i,t} - l_{\bar{c}i,t}\right)\right]$, with $x = \{mfp; d; k\}$

ICT and R&D capital demand equations

The specifications of our ICT and R&D capital demand are very simple. They are based on the long-term equilibrium relationships derived from the assumption of firms' inter-temporal maximization of their profit, augmented by the regulatory burden indicator REG.[10]

9 The non-ICT capital elasticity $\tilde{\alpha}$ is calculated as the share of the user cost of non-ICT capital over total costs. As shown in Appendix B, our results are robust when this elasticity is estimated simultaneously to the others rather than calibrated.

10 It is worth noting that the introduction of the regulatory burden indicator is not motivated by the input production marginal cost but by the competition distortion between innovative firms and followers as formalized in Bourlès *et al*. (2013) and Lopez (2011).

Assuming the Cobb-Douglas production function underlying our productivity equation we can write simply:

$$\log(P_D D/WL) = \log(\gamma/\beta) - \mu_D . REG_{-1}$$
$$\log(P_K K/WL) = \log(\delta/\beta) - \mu_K . REG_{-1}$$

where $P_D D/WL$ and $P_K D/WL$ are the user costs shares of ICT and R&D capitals relative to the labor cost share. Rewriting these equations in terms of ICT and R&D capital user cost ratios to average employee cost (or ICT-labor and R&D-labor cost ratios for short), and adding error terms including fixed effects to control for country, industry and year unobserved common factors as in the productivity equation (and with $x \equiv Log\ X$), we obtain the regression equations:

$$(d-l)_{ci,t} = \text{Cst} - (p_D - w)_{ci,t} - \mu_D REG_{ci,t-1} + u^D_{ci,t}$$
$$(k-l)_{ci,t} = \text{Cst} - (p_K - w)_{ci,t} - \mu_K REG_{ci,t-1} + u^K_{ci,t}$$

These equations are strictly consistent with the hypothesis of a Cobb-Douglas production function, implying that the elasticity of substitution between factors are all equal to 1 and that the price elasticities are constrained to be 1. Since these constraints may be too restrictive and although they do not lead to significantly different estimates of our two parameters of interest μ_D and μ_K, we actually prefer to consider equations (4) in which they are not *a priori* imposed and can be tested:

$$\begin{aligned}(d-l)_{ci,t} &= \text{Cst} - \sigma_d (p_D - w)_{ci,t} - \mu_D REG_{ci,t-1} + u^D_{ci,t} \\ (k-l)_{ci,t} &= \text{Cst} - \sigma_k (p_K - w)_{ci,t} - \mu_K REG_{ci,t-1} + u^K_{ci,t}\end{aligned} \qquad (4)$$

These equations can be viewed as deriving from a CES (Constant Elasticity of Substitution) production function, and the parameters σ_d and σ_k interpreted as elasticities of substitution between factors. Note, however, that the CES production function with more than two factors is also restrictive since it imposes that these elasticities would be the same for all pairs of factors: that is here $\sigma_d = \sigma_k$ ($= \sigma_l = \sigma_c$), which, as we will see, is not far from being the case for our results.

III. Main Data and Analysis of Variance

We now explain the construction of the central explanatory variable of our analysis: the upstream regulatory burden indicator REG and provide details on the measurement of our multifactor productivity, ICT and R&D capital variables and on our sample in Appendix A. We also present here important descriptive statistics and an analysis of variance for all the variables in terms of separate country, industry and year effects, and a relevant sequence of two-way effects.

Regulatory burden indicator

Our empirical analysis focuses on the productivity, ICT and R&D impacts of the regulatory burden indicator REG, which is constructed on the basis of the OECD Non-Manufacturing Regulations (NMR) indicators. These indicators measure "to what extent competition and firm choices are restricted where there are no a priori reasons for government interference, or where regulatory goals could plausibly be achieved by less coercive means", in six non-manufacturing industries. Referred to here as *upstream industries,* these are: energy (gas and electricity), transport (rail, road and air), communication (post, fixed and cellular communication), retail distribution, banking services and professional services. Undoubtedly they constitute the most regulated and sheltered segments of OECD countries' economies, whereas few explicit barriers to competition remain in markets for the products of manufacturing industries.

The NMR indicators are based on detailed information on laws, rules and market and industry settings, which are classified in two main areas: state control, covering specific information on public ownership and public control of business activities, and barriers to entrepreneurship, covering specific information on legal barriers to entry, market structure and or industry structure. For a given upstream industry the NMR indicators can take a minimum value of 0 in the absence of all forms of anti-competitive regulations and a maximum value of 1 in the presence of all of them, and they thus vary on a scale of 0 to 1 across countries and industries. They are also available for all years of our estimation period in energy, transport and communication, for 1998, 2003 and 2007 in retail distribution and professional services, and for 2003 only in banking. More information on the construction of the NMR indicators is given in Appendix A; and a detailed presentation can be found in Conway and Nicoletti

(2006) for all six non-manufacturing industries except banking, and in De Serres *et al*. (2006) for banking.

The NMR indicators have the basic advantage that they establish relatively direct links with policies that affect competition. Econometric studies using them to measure imperfect competition are also much less concerned by endogeneity problems that affect studies depending on traditional indicators of product market competitiveness, as mark-ups or industry concentration indices (see Boone, 2000, for a discussion of endogeneity issues in such studies).

In a macro-econometric analysis such as ours, however, NMR indicators cannot separately be used in practice to assess the upstream regulatory impacts on productivity as well as on ICT and R&D, and must therefore be combined in a meaningful way. We do this, as is customary in this field, by considering that their individual impacts are most likely to vary with the respective importance of upstream industries as suppliers of intermediate inputs. Our regulatory burden indicator REG is thus constructed in following way:

$$REG_{ci,t} = \sum_{j \neq i} NMR_{c,t}^{j} . w_i^j \; with \; w_i^j \equiv \frac{input_{i,R}^{j}}{output_{i,R}}$$

where $NMR_{c,t}^{j}$ is the NMR indicator of the upstream industry *j* for country *c* in year *t*, and w_i^j stands for the intensity-of-use of intermediate inputs from industry *j* by industry, as measured from the input–output table for a given country and year as the ratio of the intermediate inputs from industry *j* to industry *i* over the total output of industry *i*. We prefer to use a fixed reference input-output table to compute the intensity-of-use ratios rather than the different country and year input and output tables, to avoid endogeneity biases that might arise from potential correlations between such ratios and productivity or R&D and ICT, since the importance of upstream regulations may well influence the use of domestic regulated intermediate inputs. We have actually used the 2000 input-output table for the USA, already taken as a reference for the productivity gap and R&D and ICT gap variables. For similar endogeneity as well as measurement error concerns, note also that in estimating REG for the upstream industries, we exclude within-industry intermediate consumption (or $w_J^j = 0$) .

Insert Graph 1 about here

Graph 1 shows the country averages of REG for 1987, 1997 and 2007. The relatively restrictive regulations, which prevailed overall in 1987 in most countries, weakened in the two following decades in all countries at different paces. In European Union countries, this decrease of restrictive regulations is partly linked to deregulation successive decisions at the Union level, during the single market process. The cross-country variability of REG appears quite important in all three years, with the USA, UK and Sweden remaining the most pro-competitive countries and Austria and Italy followed by France in 1987 and by Canada in 2007 being the less pro-competitive countries.

Descriptive statistics and analysis of variance

Table 1 gives the means and medians, first and third quartiles for the eight variables of our productivity, ICT and R&D regressions, both in levels and annual growth rates. These statistics are computed for the complete study sample (i.e. 2,612 observations for levels and 2,430 for growth rates), except for the R&D variables computed for the subsample without industries with low R&D intensity (i.e. 1,478 observations for levels and 1,366 for growth rates). We can see in particular that on average for our sample over the twenty year period 1987-2007, REG has been reduced at a rate of 3.3% per year while the MFP gap with the USA has been slowly decreasing by 0.2% per year. In parallel, ICT capital intensity has been very rapidly increasing at a rate of 11.3% per year, while its gap with the USA has been slowly augmenting by 0.3% per year. R&D capital intensity has also been increasing at a rapid rate of 5.8% per year, while its gap with the USA has been widening very significantly by 1.5% per year. Similarly we observe that our measures of the ICT and R&D labor cost ratios have respectively been decreasing at very high rates of about 10% and 5.8% per year, which largely reflects the actual use of quality-adjusted hedonic prices for ICT and of overall manufacturing prices for R&D for lack of more appropriate prices.

Insert Table 1 about here

Table 2 summarizes the results of an analysis of variance for all the variables of our analysis in terms of separate country, industry and year effects θ_c, θ_i and θ_t, as well as a sequence of two ways interacted effects θ_{ct}, (θ_{ct} and θ_{it}) and (θ_{ct}, θ_{it} and θ_{ci}). The first column documents the R-squares of the regressions of our model variables on the three one-way effects separately, as a basic control for the usual sources of specification errors, such as

omitted (time invariant) country and industry characteristics. Thus, this column indicates the variability taken into account by the one-way fixed effects. The three following columns document what is the additional variability lost when we also include interacted two-way effects, in order to control for other potential sources of specification errors to be discussed in the next Section on identification and estimation. They are ordered in a sequence going from the most plausible source of endogeneity (2nd column), to the next most plausible source (3rd column) and to a third one (4th column) that we will argue is very unlikely.

We see that the three country, industry and year effects taken alone already account for large shares of variability of the eight variables of our model which range from 45-60% for the MFP, ICT and R&D gap variables of the productivity regression, to 75-85% for the ICT and R&D capital intensity and labor cost ratio variables, and to nearly 95% for our central explanatory variable REG. We see that the share of residual variability accounted for by interacting country and year effects alone is, at most, 45% (for the ICT-labor cost ratio, but much less for the other variables), and by interacting also industry and year effects, at most 50% (for REG and the ICT-labor cost ratio but much less for the other variables). Interacting in addition the country and industry effects accounts, in total, for up to a minimum share of 70% for all eight variables, and of 90-95% for five of them.

Insert Table 2 about here

Focusing on REG, the share of its variability in total variability decreases from 7.2% with separate country, industry and year effects, to 5.0% adding country-year effects, and to 3% adding also industry-year effects, and to 0.3% adding finally country-industry effects. In effect the absolute total variability of REG is large enough so that even a share of a few percent is sufficient to obtain estimates that are statistically significant, as we shall see in Section V. It is also fortunate that there are strong and *a priori* reasons for considering that it is very likely that the country-industry component of the data, contrary to the country-year and industry-year components, is indeed an appropriate source of exogenous variability for the estimation of our model.

IV. Identification and estimation

In order to consistently estimate the long-term impacts of REG in the productivity, R&D and ICT demand regressions (3) and (4), we have to take into consideration intricately related potential sources of specification errors, which are mainly: (i) inverse causality, when governments reacting to economic situations and political pressures implement changes in product market regulations; (ii) direct effects of such changes, insofar as they can be correlated over time within-country and across-industry as well as within-industry and across-country; (iii) omitted variables such as country specific and/or industry specific technical progress and changes in international trade, etc… We will explain in a first sub-section how we can account for such specification errors by including country*year and industry*year effects in our regressions and thus largely mitigate the biases they potentially generate. We will also argue that there is no need to control for country*industry effects, and that we can rely on the country*industry variability of the explanatory variables in our regressions to identify and estimate consistently the upstream regulatory impact parameters of interest.

To be fully confident that we are estimating long-term parameters, we also have to corroborate that our regressions are cointegrated. We also have to make sure that short-term correlations between the idiosyncratic errors in the regressions and our variables are not another possible source of biases for our estimates, in particular those of the elasticities of ICT and R&D capital intensities and relative user costs. To deal with this issue we implement the Dynamic OLS (DOLS) estimators proposed by Stock & Watson (1993). In a second sub-section we will thus briefly report on the cointegration tests we performed showing that, by and large, we can accept that our model is cointegrated, and on the Hausman specification tests of comparison of the OLS and DOLS estimates showing that the former are biased and the latter are indeed to be preferred.

Specification errors and country, industry and year interaction effects

Firms' political pressures to change regulations are an important potential source of econometric specification errors. In particular, if firms respond to negative productivity shocks by "lobbying" for keep anti-competitive regulations against the general decrease observed evrywhere, thereby protecting their rents, inverse causality could entail negative correlations between productivity and product market regulation indicators, possibly leading

to an overestimation of the negative impacts of anti-competitive regulations on productivity. Obviously, such biases could also arise and eventually be greater when estimating the regulatory impacts on demand for R&D and ICT. However, we can distinguish three cases depending on whether such productivity shocks and lobbying reactions occur over time at the country level across industries, and/or they occur at the industry level across countries, and/or they are country and industry specific.

The first case appears the most likely, because of government responses to the aggregate economic situation. Including country*year interacted effects in our regressions will offset the corresponding endogeneity biases in this case.

The second case is very similar to the first. Although probably less prevalent than the first case, it may concern particularly upstream industries such as energy, transport, communications and banking, in which international agreements and regulations are widespread. Likewise, including industry*year effects in our model will offset the resulting endogeneity biases.

The last case of potential occurrence of biases arising from lobbying and productivity shocks at specific country-industry levels would apply if we were trying to assess the impacts of existing regulations in industries on the productivity and ICT and R&D of these industries themselves. However, this analysis only focuses on estimating the impacts of regulations in upstream industries on other downstream industries. In fact, although we are estimating average impacts of upstream regulations over all industries by keeping upstream industries in our sample, we are abstracting from the possible regulatory impacts of upstream industries on their own productivity and ICT and R&D by being careful to impute a value of zero for upstream industries own intermediate consumption ($w_J^j = 0$) when measuring REG in these industries.[11]

In addition to their use in correcting for, or at least mitigating, potential endogeneity biases, it is also important to stress that country*year fixed effects and industry*year, either alone or taken together, can act as good proxies for a variety of omitted variables. In particular they can take into account differences between countries and/or industries in technical progress, in the development of labor force education and skills, in the evolution of own-industry

[11] It can be noted in this regard that the estimated negative impacts of REG are significantly higher in absolute value if we did not take such precaution than when we do, which can be taken as a confirmation of an endogeneity bias.

regulatory environments, and in changes in international trade conditions, etc…

Despite these efforts, there is another source of endogeneity that our fixed effects are not able to prevent: downstream industries that use regulated (upstream) intermediate inputs could lobby for and obtain upstream deregulation. In this case one would expect that firms in downstream industries that use most intensively the regulated upstream inputs would lobby more strongly and obtain deeper upstream deregulation. However, this would play against the conjecture that we test in this paper. Therefore, at worst the empirical results presented in this paper underestimate the negative effects of upstream regulation on downstream productivity and ICT and R&D demands.

In view of the inherent difficulties and uncertainties of our study, rather than choose one preferred econometric model specification, we considered it appropriate to keep two that provide a range of plausible consistent estimates. The first one, with only interacted country*year effects mitigates the endogeneity and omitted variables specification errors that we consider most likely and gives generally higher negative estimates (in absolute values) of the upstream regulatory impact parameters that can be viewed as "upper bound" estimates. The second with both interacted country*year and industry*year effects more fully eliminates such specification errors and give estimates that can be deemed as "lower bound" estimates.[12] In the next two sections we will center the discussion of our estimation results and simulations on these two types of estimates.

Cointegration and DOLS estimators

To support our long-term interpretation of our estimation results and our reliance on the DOLS estimators, we have to test the cointegration of our model. More precisely, we have to test that: i) MFP, R&D and ICT capital intensity and relative user cost are integrated of order 1 (I(1)); and (ii) that MFP is cointegrated with the leading country. We have performed Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) panel data unit-root tests and Pedroni (1999, 2004) panel data cointegration tests. All the unit-root tests confirm that the MFP, R&D and ICT capital intensities and user cost variables are I(1), whereas the cointegration tests are

[12] As we shall see in a few cases the upper bound estimates will be lower than the lower bound estimates, which is actually not surprising since the country*year and industry*year effects are expected to eliminate a variety of potential specification errors.

somewhat less clear-cut, four out of seven of them rejecting the no-cointegration null hypothesis. However, it is important to stress that our unit-root and panel cointegration tests have necessarily a relatively weak power because of the short time dimension of our panel data sample (maximum 20 years but on average about half that, as it is seriously unbalanced).

In principle when non-stationary variables are cointegrated, the Ordinary Least Squares (OLS) estimators are convergent under the standard assumptions (Engle and Granger, 1987). However, there are reasons to suspect that the OLS estimates of the elasticities of ICT and R&D capital intensities and the relative user costs (γ and δ) and (σ_d and σ_k) in the productivity and the demand regressions may be biased, because of short-term correlations between these variables and regression idiosyncratic errors. The DOLS estimators eliminate these correlations by including in the regressions leads and lags of the first differences of the potentially endogenous explanatory variables if they are non-stationary.[13] The Hausman specification tests implemented on the three regressions show that the OLS and DOLS estimates differ quite significantly, clearly confirming our preference for the latter.

V. Main estimation results

We now comment what we consider our upper and lower estimates for the multifactor productivity regression (3) and the ICT and R&D capital demand regressions (4), presented in a similar format in Tables 3, 4 and 5. In addition to these estimates obtained, as explained above, with the model specifications including country*year effects and both country*year and industry*year effects, we also show in these Tables, for reference, the estimates obtained when only including separate country, industry and year effects in the regressions, as usually done in country-industry panel data such as ours.

We also provide for comparison in Table 3 the estimates of the overall impact of upstream regulations on productivity that we would find if we were omitting the ICT and R&D capital intensity gap variables and not trying to assess the relative importance of the ICT and R&D channels in the overall impact of these regulations on productivity growth. In Tables 4 and 5, we similarly give the estimates we would find if we assumed that the ICT and R&D were strictly derived from a Cobb-Douglas production function.

13 Given that the time dimension of our sample is already short, we have only included one lead and one lag. Our estimates are practically unaffected when we add one or two more leads and lags.

Multifactor productivity regression

Looking first at the direct upstream regulatory impact parameter μ in Table 3 we see that the upper bound estimate (column 1) is statistically quite significant and of a high order of magnitude implying that a 0.10 decrease in the level of the regulatory burden indicator REG would contribute to a long-term average increase of 2.3% of multifactor productivity MFP, that is about as much as 0.2% per year if we assume a long-term horizon of some 12 years. The lower bound estimate (column 3) is not statistically significant and much lower, though not entirely negligible, with a magnitude implying that a 0.10 decrease in REG would contribute to a long-term average increase in MFP of 0.6% (0.05% per year).

Insert Table 3 about here

Finally, it must kept in mind that we can only estimate average parameters on our country-industry panel and that in particular the regulatory impact parameters can be quite heterogeneous across industries. In an attempt to account in part for such heterogeneity, we have considered a specification of our model in which the impact parameters in the productivity and ICT regressions could be different in the 8 industries investing both in ICT and R&D and in the 5 industries not investing significantly in R&D (and hence excluded from the estimation of the R&D regression). The results of this attempt are recorded in Appendix B in the Robustness analyses. Interestingly, we find that the lower bound estimated μ is statistically significant and high in the non-R&D industries and not in the R&D industries (respectively equal to -0.21 and -0.05). Together with the corresponding estimates for μ_D and μ_K , this is plausible evidence that in R&D industries, the R&D and ICT channels basically account for the overall upstream regulatory impact, while in the non-R&D industries other channels along with the ICT channel play the main role.

Turning now to the ICT and R&D elasticities, we see that they are precisely estimated with orders of magnitude consistent with the most reliable results in the literature. In spite of being quite precise, the upper and lower bound estimates are not statistically very different: respectively 0.05 and 0.07 for ICT and 0.08 and 0.07 for R&D.

ICT and R&D capital demand regressions

The upper and lower bound estimates of the two upstream regulatory impact parameter μ_D and μ_K (columns 1 and 3) in Tables 4 and 5 are statistically significant and of a high order of magnitude, particularly for R&D. It should be noted that the estimate we dubbed the "lower bound estimate" appears markedly higher than the upper bound estimate, but that actually the two are not statistically different because of their rather large standard errors. Taken at face value, we thus find that a 0.10 decrease in the level of the regulatory burden indicator REG would thus contribute to a longterm average increase in a range of 2.6% to 3.4% for ICT capital intensity and in a range of 8.7% to 14.0% for R&D capital intensity.

Insert Table 4 and 5 about here

The upper bound and lower estimates of the elasticities of ICT and R&D relative user costs of capital σ_d and σ_k are practically equal and quite significantly smaller than 1 in absolute value, at 0.8 for ICT and 0.6 for R&D. These estimates thus provide strong evidence rejecting the hypothesis of an underlying Cobb-Douglas production function to derive factor demand equations in favor of that of CES type production with elasticities of substitution between ICT and R&D and other factors much smaller than 1.

VI. Simulations

To illustrate the implications of our results more fully and to put them in perspective, we propose a simple and tentative simulation. This simulation can be considered as a prospective evaluation of what could be at the national level the long-term impact in terms of growth of ICT and R&D capital intensity and multifactor productivity if countries were implementing the lightest upstream anti-competitive regulatory practices.

Based on the estimates of the ICT and R&D demand regressions, we can evaluate directly for each country the gains in ICT and R&D capital intensities that would result in the long term, say 2020, from a progressive implementation of the lightest upstream regulatory practices starting from their 2007 level. Using our productivity regression estimates, we can compute both the corresponding (or indirect) multifactor productivity MFP gains working through the ICT and R&D channels, and the direct ones working through other channels. The computations of these gains are performed on the basis of both our lower and upper bound

estimates. Since they are obtained at the country-industry observation level, we have to aggregate them at the country level. We do so by weighting the 13 industries included in our sample proportionally to their 2007 Value Added to GDP ratios. We thus assume no gains from the industries excluded from our sample, which amount to some 45% of country GDP on average.

In these computations, we think it more appropriate to use a slightly modified regulatory burden indicator (REG-D) based on domestic input-output table, and not on the (REG) indicator which is based on the USA input-output table. As we have explained, we used REG in estimation in order to avoid potential endogeneity biases, but we prefer to rely on (REG-D) to take into account in our evaluation of MFP gains the differences across countries in the intensity of downstream intermediate consumption of products from regulated upstream sectors. As documented in Appendix B (Table B3), since the intensity of use of regulated upstream intermediate consumption is low in the USA, the choice of REG instead of REG-D will result in underestimation in all countries, ranging from 20% to 45% and of 30% on average.

Graphs 2 and 3 show the prospective evaluations of the upper and lower bound long term regulatory impacts on the growth of ICT and R&D capital intensities for the 15 countries of our sample as if they were implementing the lightest upstream anti-competitive regulatory practices. These impacts are much larger for R&D than for ICT: on average fourfold for the upper bound evaluations and threefold for the lower bound ones. They are, for example, in the case of R&D, highest for Italy and Austria, ranging respectively from about 60% to 90% and from about 50% to 80%, and lowest for the United Kingdom and the USA, ranging from about 15% to 20% in both countries. In the case of ICT, the upper and lower bound estimates are close, highest for Italy and Austria and lowest for the United Kingdom and the USA, respectively around 15-20% and 2-5%. The ranking of the countries from the lowest to highest impacts for R&D and ICT are almost the same, and reflects closely enough, as could be expected, the country ranking in terms of the regulatory burden indicator REG-D (and practically also REG).

Graph 2 and 3 about here

In the same format as the two preceding graphs, Graph 5 presents the prospective evaluations of the upper and lower bound long-term regulatory impacts on the growth of multifactor

productivity MFP for the 15 countries of our sample, under the assumption they have implemented the lightest upstream anti-competitive regulatory practices. It shows not only the total impacts, but also the corresponding indirect and direct impacts which are respectively working through the ICT channel, the R&D channel and other channels.

Graph 4 about here

We can see that upper bound evaluations of the total productivity impact are much higher than the lower bound evaluations: on average by about 6.5% as against 2.5%, that is about 0.5% as against 0.2% per year if we assume a long term horizon of some 12 years. They are highest for Italy and the Czech Republic of about 11-13% versus 4-5% (roughly 1% and 0.4% per year), and they are lowest for the UK and the USA with about 2-3% versus 1% (roughly 0.5% and 0.1% per year). We also observe that the upper bound evaluations of the direct impacts are much higher, by a factor of about 2.5 on average, than those of indirect impacts of ICT and R&D together, while the lower bound evaluations of the direct impacts are also higher, by 25% on average, than those of the indirect impacts. Since the regulatory impacts on R&D are much larger than on ICT and the productivity elasticities of ICT and R&D capital are not too different, we can make a last observation that the indirect productivity impacts for R&D are greater than for ICT.

VII. Conclusions

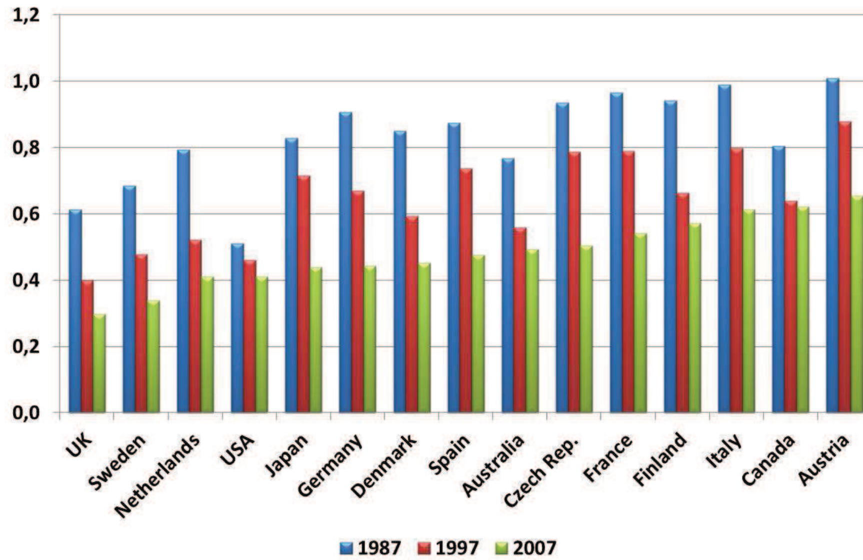
In this paper we have investigated empirically through which channels and mechanisms upstream industry anti-competitive regulations impact productivity. To our knowledge, this is the first attempt to address this important and challenging question. Using a country-industry unbalanced panel dataset that is as comprehensive as we could reasonably construct it, and relying mainly on an upstream regulatory burden indicator built from the OECD Non-Manufacturing Regulations (NMR) indicators, we have assessed the actual importance of the two main channels usually contemplated in the literature through which upstream sector anti-competitive regulations may impact productivity growth by acting as a disincentive for business investments in R&D and in ICT.

As usual there are limitations to our study and its findings and many directions in which it could be extended and improved for a better understanding of the relations between product market regulations and productivity and for specific policy implications. In particular it will be worthwhile, if more comprehensive and detailed data would permit, to assess the productivity impacts of upstream regulation on different channels beyond the ICT and R&D channels that we have assessed here, focusing on different industries and different types of product market regulation (beyond the two limited attempts presented in Appendix B). Another dimension that is important to take into account is labour market regulations. Several studies (see among others Aghion *et al.* 2009) have shown that labour market regulations could impact productivity either directly or through an interaction with product market regulations, and the large impacts of the upstream industry regulations on productivity we have found could also be linked to labour market regulations.

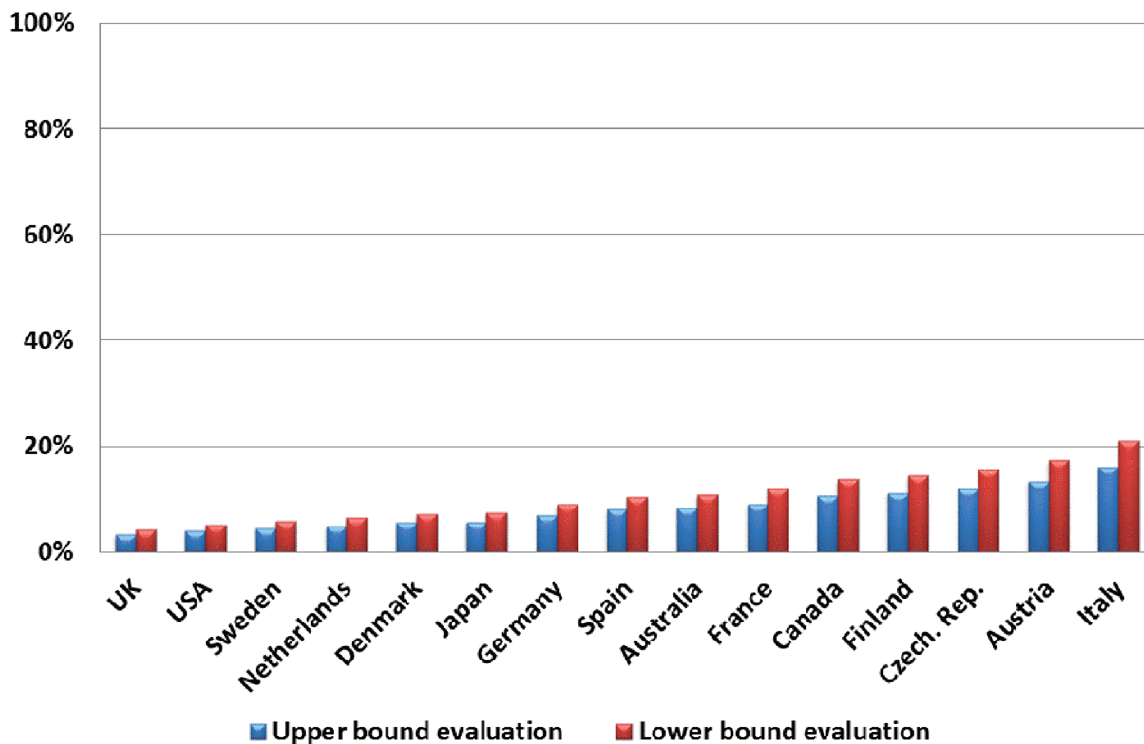
We are nevertheless convinced that we could not go much further in such directions with our country-industry aggregate data and in our present framework on the basis of the OECD product market indicators. Still with the same data and framework, one possibility we may explore is to confirm and enrich our present findings by relying on the more traditional accounting measures of product and labor market measures despite the endogeneity issues that this will raise. Clearly, in order to go much beyond this type of macro-economic research, one would need to perform micro-econometric analyses of firm data for different countries and industries.

Graphs 1 to 4 and Tables 1 to 5

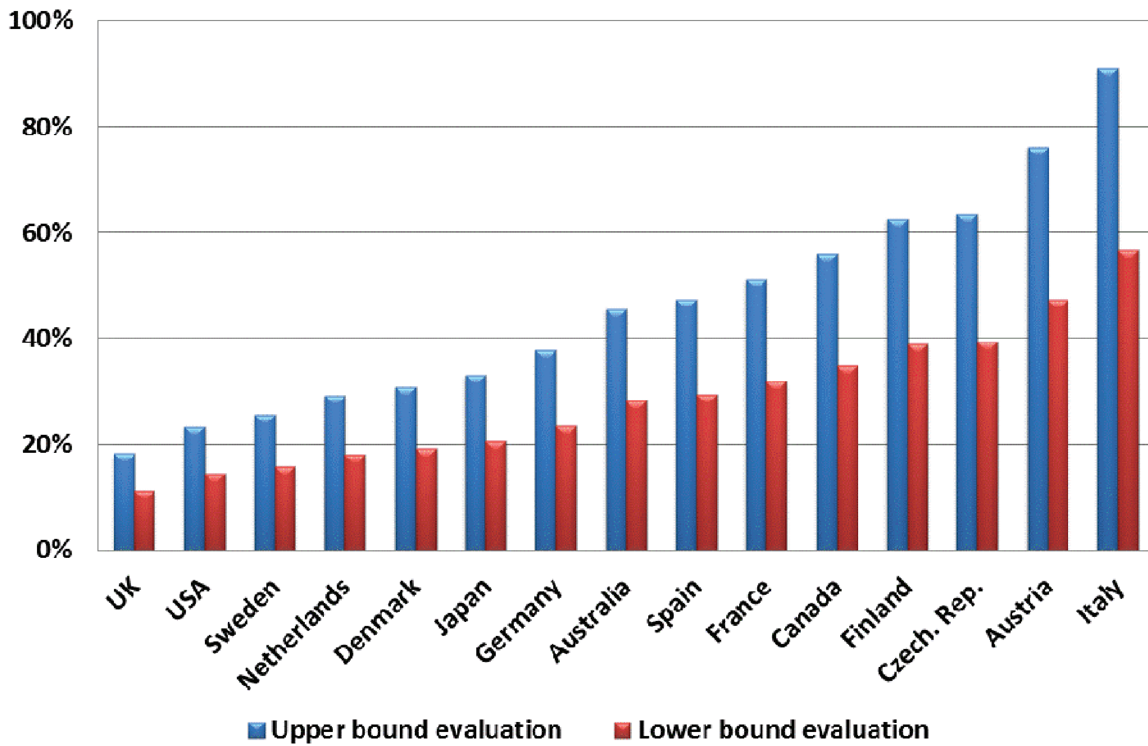
Graph 1: Country averages of REG in 1987, 1997 and 2007



Graph 2: Simulated long-term regulatory impacts on ICT capital



Graph 3: Simulated long-term regulatory impacts on R&D capital



Graph 4: Simulated long-term regulatory impacts on multifactor productivity

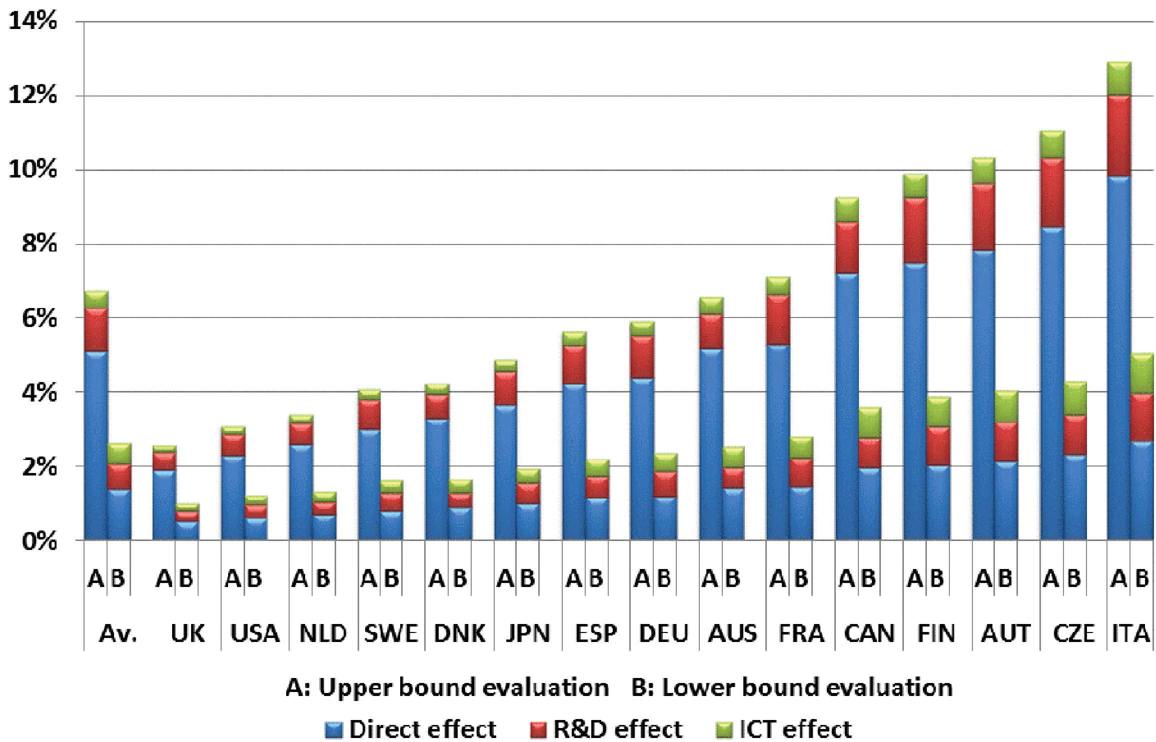


Table 1: Simple descriptive statistics

	Levels in logs except for REG				Annual log growth rate in % also for REG			
	Q1	Median	Q3	Mean	Q1	Median	Q3	Mean
Regulatory burden indicator REG	0.40	0.65	0.89	0.65	-4.75	-2.62	-1.17	-3.33
MFP gap	-0.55	-0.39	-0.25	-0.42	-4.06	-0.20	3.59	-0.20
ICT capital intensity gap	-1.10	-0.75	-0.27	-0.73	-5.22	-0.13	5.30	0.28
R&D capital intensity gap	-1.28	-0.54	-0.04	-0.62	-4.94	1.01	7.02	1.55
ICT capital intensity	5.30	5.96	6.74	6.01	5.93	10.39	15.55	11.34
ICT - labor cost ratio	-0.18	0.18	0.61	0.24	-16.20	-9.11	-2.94	-9.98
R&D capital intensity	5.63	6.52	7.65	6.54	1.06	5.12	10.22	5.85
R&D - labor cost ratio	-0.07	0.03	0.18	0.05	-7.18	-3.10	0.73	-3.28

All statistics are computed for the complete study sample, except for the R&D variables computed for the subsample without industries with low R&D intensity.

Table 2: Analysis of variance

	First step R^2	Second Step R^2		
	Separate country, industry and year effects	Country*year	Country*year and industry*year	Country*year, industry*year and country*industry
	(1)	(2)	(3)	(4)
Regulatory burden indicator REG	0.938	0.196	0.520	0.959
MFP gap	0.471	0.083	0.235	0.840
ICT capital intensity gap	0.458	0.093	0.209	0.915
R&D capital intensity gap	0.606	0.017	0.112	0.937
ICT capital intensity	0.824	0.095	0.1620	0.9120
ICT - labor cost ratio	0.837	0.4470	0.507	0.801
R&D capital intensity	0.790	0.018	0.070	0.9360
R&D - labor cost ratio	0.758	0.217	0.265	0.690

See footnote to Table 1.

Table 3: Multifactor productivity regression

Dependent variable: **MFP gap**	(1)	(2)	(3)	(4)	(5)	(6)
ICT capital intensity gap	0.047*** [0.008]		0.052*** [0.009]		0.073*** [0.009]	
R&D capital intensity gap	0.081*** [0.007]		0.076*** [0.007]		0.067*** [0.007]	
Regulatory burden indicator REG	-0.216*** [0.050]	-0.209*** [0.051]	-0.226*** [0.055]	-0.248*** [0.057]	-0.075 [0.067]	-0.161** [0.071]
Effects:						
Country, industry, year separately	Y	Y	Y	Y	Y	Y
Country*year	Y	Y	Y	Y	N	N
Industry*year	N	N	Y	Y	N	N
Observations	2633	2633	2633	2633	2633	2633
R-squared	0.532	0.485	0.57	0.526	0.648	0.602
RMSE	0.1824	0.1909	0.183	0.1915	0.1731	0.1838

*** significant at 1%; ** significant at 5%; *significant at 10% - Newey-West standard errors between brackets. The DOLS estimates are performed with one lag and one lead of the first differences of the ICT and R&D capital intensity gap variables; the corresponding coefficients are not presented in the Table.

Table 4: ICT capital demand regression

Dependent variable: **ICT capital intensity**	(1)	(2)	(3)	(4)	(5)	(6)
ICT capital user cost	-0.870*** [0.037]	-1 [0.000]	-0.840*** [0.041]	-1 [0.000]	-0.811*** [0.045]	-1 [0.000]
Regulatory burden indicator REG	-0.112 [0.108]	-0.099 [0.109]	-0.397*** [0.122]	-0.362*** [0.122]	-0.656*** [0.161]	-0.665*** [0.161]
Effects:						
Country, industry, year separately	Y	Y	Y	Y	Y	Y
Country*year	Y	Y	Y	Y	N	N
Industry*year	N	N	Y	Y	N	N
Observations	2633	2633	2633	2633	2633	2633
R-squared	0.857	0.845	0.868	0.837	0.874	0.824
RMSE	0.4055	0.4064	0.4066	0.4078	0.4174	0.419

See footnote to Table 3.

Table 5: R&D capital demand regression

Dependent variable: **R&D capital intensity**	(1)	(2)	(3)	(4)	(5)	(6)
R&D capital user cost	-0.614*** [0.109]	-1 [0.000]	-0.630*** [0.129]	-1 [0.000]	-0.625*** [0.136]	-1 [0.000]
Regulatory burden indicator REG	-0.675** [0.283]	-0.788*** [0.283]	-1.367*** [0.385]	-1.535*** [0.382]	-0.859** [0.426]	-1.041** [0.422]
Effects:						
Country, industry, year separately	Y	Y	Y	Y	Y	Y
Country*year	Y	Y	Y	Y	N	N
Industry*year	N	N	Y	Y	N	N
Observations	1491	1491	1491	1491	1491	1491
R-squared	0.795	0.763	0.800	0.746	0.808	0.787
RMSE	0.6316	0.6341	0.6679	0.6698	0.6866	0.6886

See footnote to Table 3.

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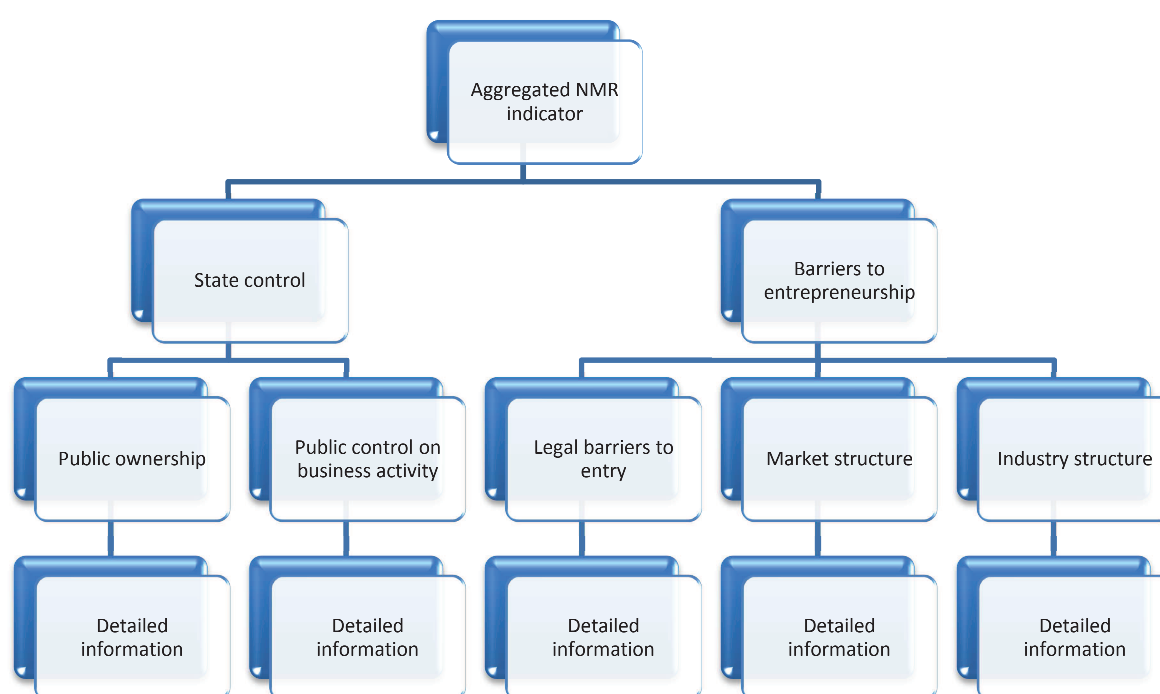
APPENDIX A: DATA

In this Appendix, we first provide additional information on the underlying OECD Non-Manufacturing Regulation (NMR) indicators for a better understanding of the regulatory burden indicator REG. We then explain the measurement of the ICT, non-ICT and R&D capital stocks, and that of our multifactor productivity variable MFP, and we document the construction of our sample.

(1). Non-manufacturing product market regulation indicators

Chart A1: Aggregation of the detailed information on regulations



The OECD Non-Manufacturing Regulations (NMR) indicators measure to what extent competition and firm choices are restricted where there are no a priori reasons for government interference, or where regulatory goals could plausibly be achieved by less coercive means. They are based on detailed information on laws, rules and market and industry settings. This information is the raw material allowing calculation of the aggregate indicators according to the Chart A1. For each NMR indicator, the detailed information is first aggregated into five sub-level indicators: public ownership, public control on business activity, legal barriers to entry, market structure and industry structure, or eventually only part of them in some upstream industries (see Conway and Nicoletti, 2006). These sub-level indicators are then aggregated into one indicator for each upstream industry. As shown in the diagram, they can

also be aggregated at the level of 'state control' on the one hand and 'barriers to entrepreneurship' on the other for each upstream industry. We have considered these two levels in an attempt to differentiate the impacts of both kind of regulations which we discuss briefly in Appendix B.

Table A1 gives the example of the questions and corresponding weights involved in the construction of the 'legal barriers to entry' sub-level regulation indicator for professional services. The answers to each question are coded between 0 and 6. These codes are indicated in the Table under each possible answer, with 0 for the most procompetitive regulation and 6 for the most anti-competitive one.

Table A1: Construction of the 'legal barriers to entry' sub-level regulation indicator for Professional services

Scale 0-6, with 0 for the most pro-competitive regulations

	Weights by theme (b_j)	Question weights (c_k)	Coding of data				
Licensing:	2/5						
How many services does the profession have an exclusive or shared exclusive right to provide?			0	1	2	3	>3
		1	0	1,5	3	4,5	6
Education requirements (only applies if Licensing not 0):	2/5						
What is the duration of special education/university/or other higher degree?		0.33	equals number of years of education (max of 6)				
What is the duration of compulsory practice necessary to become a full member of the profession?		0.44	equals number of years of compulsory practice (max of 6)				
Are there professional exams that must be passed to become a full member of the profession?		0.22	no			Yes	
			0			6	
Quotas and economic needs tests	1/5						
Is the number of foreign professionals/firms permitted to practice restricted by quotas or economic needs tests?			no			Yes	
		1	0			6	

The coding of each question is indicated under each possible answer.

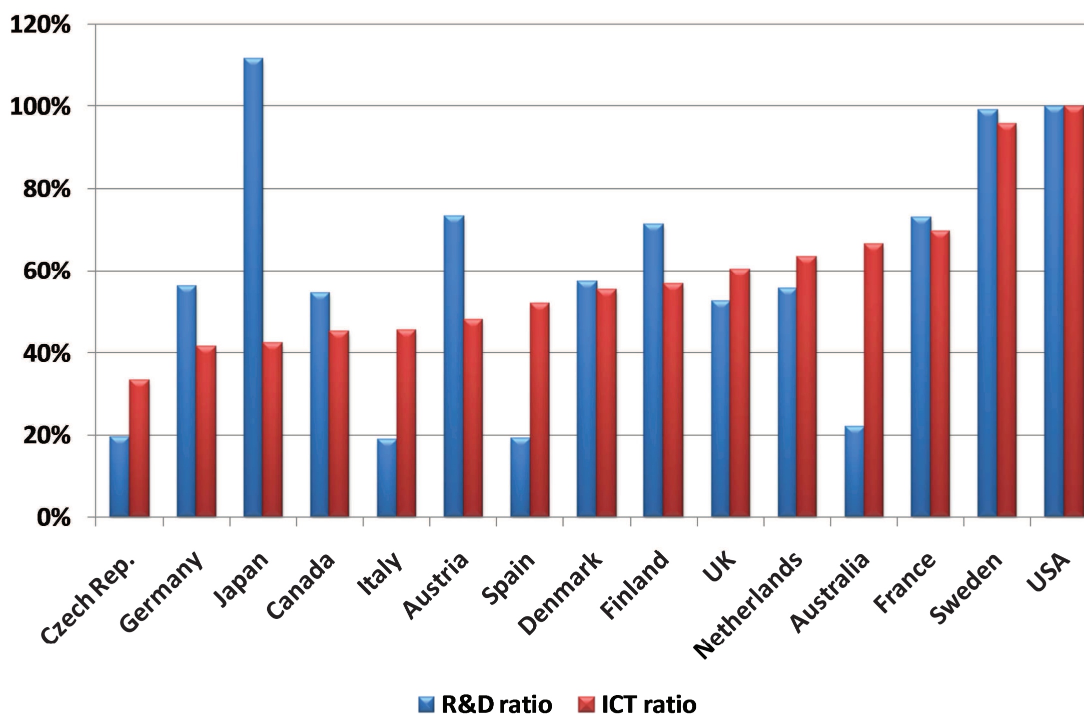
(2). Capital stocks

Data on R&D investments at the country-industry level come from the OECD ANBERD database whereas physical investments values and prices come from the EU KLEMS database. To compute investments in constant prices we have used investment deflators at the national level. Because of the lack of specific price information for R&D, we have used as a proxy the manufacturing production deflator from the OECD STAN database. For the ICT investments in hardware, software and telecommunications equipment, we have assumed for all countries that the ratio of investment prices over the GDP price is the same as for the USA. This is much better for comparability since the USA is by far the country that most extensively relies on hedonic methods to measure these prices.

Capital stocks are calculated at the level of the three ICT factors and the three non-ICT investment series in constant prices obtained from the EU-KLEMS database, using the so-called Permanent Inventory Method (PIM) and assuming constant geometric rates of depreciation: 5% for non-residential structures, 10% for transport and other non-ICT equipment, 15% for communication equipment, 25% for R&D and 30% for hardware and software. We then aggregate them into non-ICT and ICT capital stocks. R&D capital is computed in the same way using a depreciation rate of 25%. To implement the PIM we need an initial capital stock estimate. For ICT capital stocks, we simply assumed an initial capital stock of zero in 1971. Investment series at the industry level are available for non-ICT physical assets since 1970 and for R&D only since 1987. We thus first estimated an R&D capital stock at the aggregate level which we could do for 1981 and apportioned it to the different industries proportionally to their shares in total R&D investment in 1987. Note that to estimate the initial capital stocks K_0 of non-ICT physical capital per industry in 1970 and of aggregate R&D capital in 1981, we used the formula $K_0 = I_0^q/(\delta + g)$ with I_0^q the investment in constant price the first year available, δ the depreciation rate and g the value added growth rate over the previous decade.

Chart A2 shows the average R&D and ICT capital intensities (i.e. R&D or ICT capital stocks per employee) by country relative to the USA (=100%), where these ratios are computed on the 2001-2005 period, for which our sample is nearly balanced. We observe very large differences between countries and in their ranking by R&D and ICT capital intensities.

Chart A2: R&D and ICT capital intensity ratios relative to the USA (=100%) country average 2001-2005



<u>(3). Multifactor productivity</u>

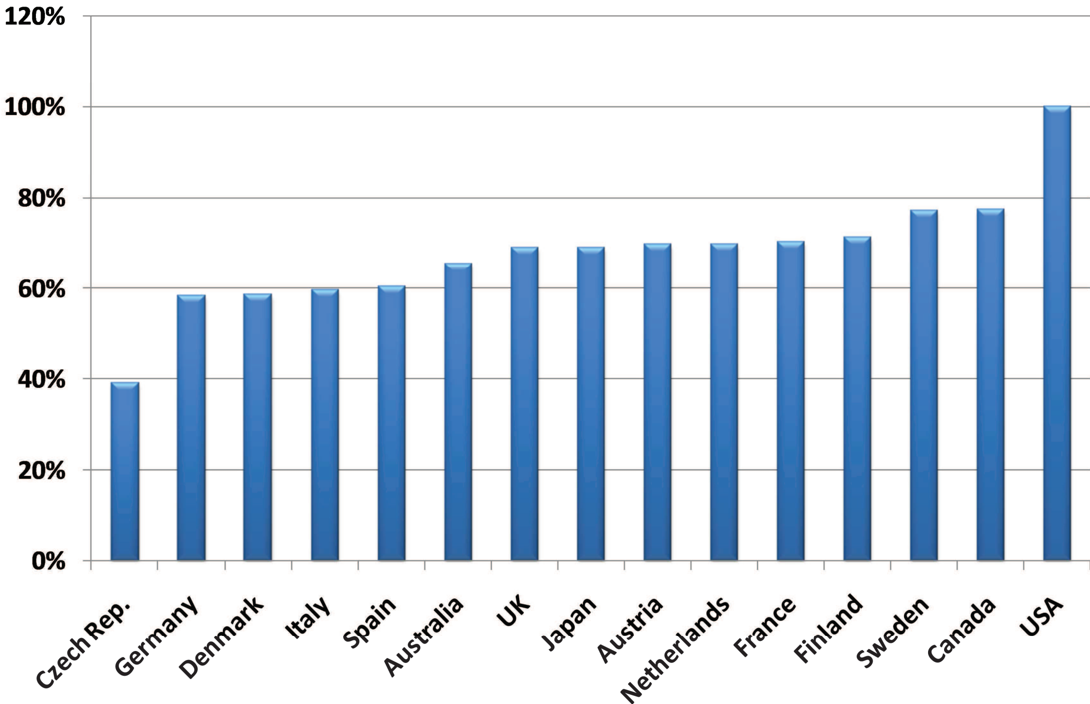
The measurement of our multifactor productivity MFP requires data at the country-industry level on value added in constant price and employment in number of persons in addition to non-ICT capital stocks. These data come from the OECD STAN database, but they need a number of corrections. Since R&D is not treated as in investment in the national accounts data gathered by OECD, we had to correct (to avoid "double counting"): (i) the industry value added by adding ("expensing out") the intermediate consumption of their R&D activities; (ii) the industry number of employees by subtracting the number of R&D personnel; and (iii) the total wages by subtracting the R&D personnel wages. Note also that we also had to modify the price index of value added, and hence its value in constant price, for the "Electrical and optical equipment" industry. This industry includes communication and computing equipment, for which prices are extensively based on the hedonic price method in the USA, but not to the same extent in other countries. It appeared that indeed the differences in the evolution of the value added price in this industry between the USA and the other countries – and hence also in the labor productivity growth – were much too large to be credible. We

therefore assumed for the other countries in this industry that the ratio of value added prices over the GDP price is the same as for the USA, as we did for the ICT investment.

To compute MFP, as explained in Section II, we have chosen to calibrate the non-ICT capital stock elasticities ($\tilde{\alpha}_i$) at the industry level by the average shares of their user cost in total costs computed for the USA over the whole estimation period. It is important, however, to stress that our main results remain basically unchanged when instead of calibrating the non-ICT capital elasticity, we estimate it in the productivity equation and do not impose the constant returns to scale hypothesis (see Appendix Table B1).

Finally, in order to ensure comparability across countries of our measure of MFP, we have converted the value added and capital stocks level variables into prices denominated in a common currency using OECD aggregate purchasing power parities. Chart A3 shows the average country MFP relative to the USA (=100%) for the 2001-2005 period. We see that MFP in the USA is much greater than all the other countries, with an average MFP ratio ranging between a low 40% for the Czech Republic and a high 80% for Sweden and Canada. At the country-industry-year level, the USA MFP is also the highest for 85% of the observations and among the three highest for the 15% other observations.

Chart A3: MFP ratio relative to the USA (=100%), country average 2001-2005



(4). Country-industry panel data sample

On the basis of the OECD STAN data base, we can consider eighteen manufacturing and service industries, covering the whole business economy, with the exception of 'Agriculture, hunting, forestry and fishing', 'Mining and quarrying' and 'Real Estate activity'. Table A2 lists these 18 industries with the industry averages for ICT and R&D investment to value added ratios over the years 2001-2005.

Table A2: Sample composition per industry and ICT and R&D investment to value added ratios, industry averages over the 2001-2005 period

INDUSTRIES	In Sample	ISIC rev. 3 code	ICT ratio (%).	R&D ratio (%).
FOOD PRODUCTS, BEVERAGES AND TOBACCO	I*	15-16	1,6	1,1
TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	E	17-19	1,2	1,2
WOOD AND PRODUCTS OF WOOD AND CORK	E	20	1,1	0,4
PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	I*	21-22	2,8	0,6
CHEMICAL, RUBBER, PLASTICS AND FUEL PRODUCTS	I	23-25	1,8	8,1
OTHER NON-METALLIC MINERAL PRODUCTS	I	26	1,4	1,4
BASIC METALS AND FABRICATED METAL PRODUCTS	I	27-28	1,5	1,3
MACHINERY AND EQUIPMENT, N.E.C.	I	29	2,2	5,01
ELECTRICAL AND OPTICAL EQUIPMENT	I	30-33	4,3	16,0
TRANSPORT EQUIPMENT	I	34-35	2,2	10,3
MANUFACTURING NEC; RECYCLING	E	36-37	1,4	1,4
ELECTRICITY GAS AND WATER SUPPLY	I	40-41	2,7	0,4
CONSTRUCTION	E	45	0,7	0,1
WHOLESALE AND RETAIL TRADE; REPAIRS	I*	50-52	2,1	0,2
HOTELS AND RESTAURANTS	E	55	1,0	0,0
TRANSPORT, STORAGE, POST AND TELECOMMUNICATIONS	I*	60-64	6,6	0,5
FINANCIAL INTERMEDIATION	I*	65-67	5,7%	0,3
RENTING M&EQ AND OTHER BUSINESS ACTIVITIES	I	72-74	4,7	1,9

I: Industries included in the sample; I*: Industries with ICT investment but almost no R&D investment included in the sample but not used in the estimation of the R&D demand; E: Industries with almost no ICT and R&D investments excluded from the sample. Upstream industries are underlined

The five industries (listed with an E in the 2nd column) have very low ICT and R&D to value added ratios, respectively 1.1% and 0.6% on average, as against 3.1% and 3.6% for the thirteen other industries. We had to exclude them from our study since we could not measure

reliably enough our ICT and R&D capital stocks variables. Our study sample thus covers the thirteen other industries (with an I or I* in the 2nd column). Among them, however, there are still five of them (with an I* in the 2nd column) that are almost not investing in R&D with very low R&D to value added ratios of 0.6% on average as against 5.5% for the eight others industries. We had to exclude them when estimating the R&D demand equation.

APPENDIX B: ROBUSTNESS AND EXTENSION ANALYSES

This Appendix briefly presents three robustness and two extension analyses we thought important to perform and document. (1) We study how much our main results vary if we estimate also the non-ICT capital and labor elasticities in the productivity equation and we do not impose constant returns to scale, nor calibrate the non-ICT capital elasticity. (2) We similarly investigate what differences it makes in our results to specify more symmetrically the productivity and ICT and R&D demand equations by introducing explicitly a "catch-up" variable in these equations. (3) We also report the differences it makes in evaluations of the long-term MFP gains by country when we use in our prospective simulation the regulatory burden indicator REG based on the USA input-output table as we have done in estimation. (4) We document how much the estimated impact of upstream regulations in the productivity and ICT demand equations differs between industries investing or not in R&D. (5) Similarly we compare the estimated impact of upstream regulations in the productivity and ICT and R&D demand equations when we separate the "state control" and "barriers to entrepreneurship" components in our regulatory burden indicator REG.

(1). Robustness with respect to the hypothesis of constant returns to scale and the decision to calibrate the non-ICT capital elasticity

In specifying and estimating our productivity equation (relation (3) in Section II), we have assumed constant returns to scale and we have calibrated the non-ICT capital elasticity by its share of total costs. We show that, on the whole, our estimation results are sufficiently robust if we estimate the following productivity equation in terms of the labor productivity (LP) gap, instead of the multifactor productivity (MFP) gap:

$$lp_gap_{ci,t} = \pi l_gap_{ci,t} + \alpha c_gap_{ci,t} + \gamma d_gap_{ci,t} + \delta k_gap_{ci,t} - \mu\, REG_{ci,t-1} + u_{ci,t}$$

with: $lp_gap_{ci,t} \equiv (y_{ci,t} - l_{ci,t}) - (y_{\bar{c}i,t} - l_{\bar{c}i,t})$, $c_gap_{ci,t} \equiv (c_{ci,t} - l_{ci,t}) - (c_{\bar{c}i,t} - l_{\bar{c}i,t})$, $l_gap_{ci,t} \equiv l_{ci,t} - l_{\bar{c}i,t}$ and $\pi \equiv \alpha + \gamma + \delta + \beta - 1$

We therefore have to estimate two further parameters: π, that is the deviation to 1 of the elasticity of scale, previously assumed to be null under constant returns to scale, and α, the non-ICT capital elasticity.

Table B1 recalls the upper and lower bound estimates previously obtained (Table 3 in the text) in columns (1) and (5) respectively, and presents the new ones in columns (4) and (8). In columns (2) and (6) it gives the corresponding estimates when the hypothesis of constant returns to scale is relaxed and the non-ICT capital elasticity remains calibrated, and in columns (3) and (7) when the reverse scenario is tested.

We see that the estimated impacts of the elasticity of scale and non-ICT capital intensity gaps are close to what we assumed them to be: π is next to zero and α is a little smaller than its average calibrated value. Our estimates of our main parameter of interest are not substantially changed: the ICT capital elasticity γ and the impact of upstream regulations μ remain roughly the same, and the R&D elasticity δ is lower but still significantly positive.

Table B1: **Robustness to production function constant returns to scale assumption and non-ICT capital elasticity calibration**

Dependent variable	**MFP gap**		**LP gap**		**MFP gap**		**LP gap**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gap in labor		-0.013 [0.013]		-0.022 [0.013]		-0.025* [0.013]		-0.034** [0.014]
Gap in non-ICT capital intensity			0.177*** [0.013]	0.190*** [0.013]			0.171*** [0.013]	0.185*** [0.013]
Gap in ICT capital intensity	0.052*** [0.009]	0.062*** [0.009]	0.046*** [0.009]	0.051*** [0.009]	0.073*** [0.009]	0.080*** [0.009]	0.065*** [0.009]	0.070*** [0.009]
Gap in R&D capital intensity	0.076*** [0.007]	0.075*** [0.007]	0.081*** [0.007]	0.078*** [0.007]	0.067*** [0.007]	0.065*** [0.007]	0.073*** [0.007]	0.070*** [0.007]
Regulatory burden indicator$_{-1}$	-0.226*** [0.055]	-0.240*** [0.055]	-0.251*** [0.055]	-0.260*** [0.055]	-0.075 [0.067]	-0.092 [0.067]	-0.128* [0.067]	-0.128* [0.068]
Fixed effects:								
Country, industry, year	Y	Y	Y	Y	Y	Y	Y	Y
Country*year	Y	Y	Y	Y	Y	Y	Y	Y
Industry*year	N	N	N	N	Y	Y	Y	Y
Observations	2633	2633	2632	2632	2633	2633	2633	2633
R-squared	0.57	0.583	0.626	0.633	0.648	0.657	0.689	0.695
RMSE	0.183	0.1804	0.1807	0.1792	0.1731	0.1711	0.1725	0.171

See footnote to Table 3.

(2). Robustness with respect to "catch-up" hypotheses

The specification of our multifactor productivity equation assumes for given fixed effects a bounded cointegrated long-term relationship between the MFP of the reference or "leader" country and the MFP of the "follower" countries by imposing a coefficient of 1 for the MFP of the reference country, or catch-up term, and writing the estimated equation in terms of MFP gap (see section II). We have specified differently the long term ICT and R&D demand equations considering that common shocks are already taken into account by the price effects and the different fixed effects and implicitly assuming a coefficient equal to zero for the catch-up term. We investigate the influence of these assumptions on our main parameter estimates and find that overall they are robust

We thus estimate now the following multifactor productivity and ICT and R&D demand equations:

$$mfp_{ci,t} = cst + \rho\left(mfp_{\bar{c}i,t} - \gamma(d_{\bar{c}i,t} - l_{\bar{c}i,t}) - \delta(k_{\bar{c}i,t} - l_{\bar{c}i,t})\right) + \gamma(d_{ci,t} - l_{ci,t}) + \delta(k_{ci,t} - l_{ci,t}) - \mu\, Reg_{ci,t-1} + u_{ci,t}$$

and

$$(d-l)_{ci,t} = \mathrm{Cst} + \varphi_1(d-l)_{\bar{c}i,t} + (p_D - w)_{ci,t} - \mu_D REG_{ci,t-1} + u^D_{ci,t}$$
$$(k-l)_{ci,t} = \mathrm{Cst} + \varphi_2(k-l)_{\bar{c}i,t} + (p_K - w)_{ci,t} - \mu_K REG_{ci,t-1} + u^K_{ci,t}$$

These equations are strictly equivalent to our previous ones, if $\rho = 1$, $\varphi_1 = 0$ and $\varphi_2 = 0$.

Tables B2.1 and B2.2 recall our previous upper bound estimates for these three equations and show the new ones. Our lower bound estimates are strictly the same, since the interacted industry*year effects fully offset the catch up variables. Although the estimated ρ of 0.87 is significantly smaller than 1 and the estimated φ_2 of 0.25 is significantly higher than 0 (while the estimated φ_1 of -0.15 is not), we see that the ICT and R&D capital elasticity as well as the impact of upstream regulations remain basically unchanged.

Table B2.1: Robustness of the multifactor productivity equation estimates with respect to catch-up hypothesis

Dependent variable	MFP gap	MFP
	(1)	(2)
Gap in ICT capital intensity	0.047*** [0.008]	0.046*** [0.008]
Gap in R&D capital intensity	0.081*** [0.007]	0.077*** [0.007]
Regulatory burden indicator$_{-1}$	-0.216*** [0.050]	-0.180*** [0.051]
MFP USA		0.869*** [0.016]
Fixed effects: Country, industry, year Country*year Industry*year	 Y Y N	 Y Y N
Observations R-squared RMSE	2633 0.532 0.1824	2633 0.562 0.1709

See footnote to Table 3.

Table B2.2: **Robustness of the ICT and R&D demand equation estimates with respect to catch-up hypothesis**

Dependent variable	ICT capital intensity	ICT capital intensity	R&D capital intensity	R&D capital intensity
	(1)	(2)	(3)	(4)
ICT or R&D capital costs	-0.840*** [0.041]	-0.845*** [0.041]	-0.630*** [0.129]	-0.617*** [0.129]
Regulatory burden indicator$_{-1}$	-0.397*** [0.122]	-0.449*** [0.126]	-1.367*** [0.385]	-1.369*** [0.390]
ICT or R&D capital intensity USA		-0.146 [0.091]		0.253*** [0.096]
Fixed effects: Country, industry, year Country*year Industry*year	 Y Y N	 Y Y N	 Y Y N	 Y Y N
Observations R-squared RMSE	2633 0.868 0.4066	2633 0.869 0.4064	1491 0.8 0.6679	1491 0.801 0.6665

See footnote to Table 3.

(3). Differences in the prospective simulations of multifactor productivity gains with respect to the choice of domestic or USA input-output tables

We finally report the differences to evaluations of the long-term MFP gains per country if instead of using in our prospective simulation the slightly modified regulatory burden indicator REG-D based on the different country input-output tables, we use in our prospective simulation the regulatory burden indicator REG based on the USA input-output table, as in estimation.

Table B3: Simulated long term MFP gains from reforms, depending on I-O tables

Simulated MFP gains	Upper-bound estimate (1)	Upper-bound estimate (2)	Lower-bound estimate (3)	Lower-bound estimate (4)
	Domestic I-O table	USA I-O table	Domestic I-O table	USA I-O table
UK	2,6%	1,7%	1,0%	0,7%
USA	3,1%	3,1%	1,2%	1,2%
Netherlands	3,4%	2,8%	1,3%	1,1%
Sweden	4,1%	3,0%	1,6%	1,2%
Denmark	4,3%	3,6%	1,6%	1,4%
Japan	4,9%	3,8%	1,9%	1,5%
Spain	5,6%	3,8%	2,2%	1,5%
Germany	5,9%	4,4%	2,4%	1,7%
Australia	6,6%	4,6%	2,5%	1,7%
France	7,1%	5,7%	2,8%	2,2%
Canada	9,2%	7,5%	3,6%	2,9%
Finland	9,9%	6,8%	3,9%	2,6%
Austria	10,3%	7,6%	4,1%	2,9%
Czech. Rep.	11,1%	5,9%	4,3%	2,2%
Italy	12,9%	7,2%	5,0%	2,8%
Country Average	6,7%	4,8%	2,6%	1,8%

Table B3 recalls in columns (1) and (3) the prospective evaluations of the upper and lower bound long term regulatory impacts in total (i.e. through all channels) on the growth of multifactor productivity MFP for the 15 countries in our sample, under the assumption they have implemented the lightest upstream anti-competitive regulatory practices (as shown in Graph 5 in the text). It compares them to the alternative corresponding evaluations given in columns (2) and (4). We see that the choice of the input-output table of the USA to compute the regulatory burden indicator of each country would have implied (since the intensity of use of regulated intermediate inputs is relatively less in this country) much lower simulated

evaluations, by about 20% (in the case of Netherlands) to nearly 50% (for the Czech Republic). Nevertheless, these evaluations still appear substantial, ranging on average from long-term MFP gains between 1.8% and 2.6% as against 4.8% and 6.7%.

(4). Differences in the impacts of upstream regulations between R&D investing and non-R&D investingindustries

As we have explained (see Appendix Table A2), while all thirteen industries in our study sample investing in ICT, only eight of them invest in R&D. Although we cannot investigate thoroughly the potential differences in the impacts of upstream regulations across industries with our aggregate country-industry data, it seems appropriate to check whether these impacts differ significantly between the two groups of R&D and non-R&D investing industries.

Tables B4.1 and B4.2 recall our previous upper and lower bound estimates for the productivity and ICT demand equations in columns (1) and (3) and contrast them to the new ones in columns (2) and (4), our estimates for the R&D demand equation remaining of course the same (see Table 5 in the text). We see that the upper bound estimates of upstream regulation impacts show marked differences between the two groups of R&D and non-R&D investing industries, although they are not statistically significant since they are not too precisely estimated: about -0.24 as against -0.19 for multifactor productivity and -0.49 as against -0.37 for ICT capital intensity. These differences are wider and statistically significant for our lower bound estimates for multifactor productivity: about -0.05 as against -0.21.

In total, we thus find reasonably strong as well as a priori very plausible evidence that upstream regulation affect productivity mainly through the R&D and ICT channels in the R&D investing industries, and mainly through other channels in the non R&D industries.

Table B4.1: Differences in upstream regulation impacts on multifactor productivity between R&D and non-R&D investing industries

Dependent variable: MFP gap		(1)	(2)	(3)	(4)
Gap in ICT capital intensity		0.052*** [0.009]	0.053*** [0.009]	0.073*** [0.009]	0.072*** [0.009]
Gap in R&D capital intensity		0.076*** [0.007]	0.075*** [0.007]	0.067*** [0.008]	0.070*** [0.008]
Regulatory burden indicator$_{-1}$	**All industries**	-0.226*** [0.054]		-0.075 [0.062]	
	R&D industries		-0.239*** [0.055]		-0.054 [0.062]
	no-R&D industries		-0.188*** [0.067]		-0.211*** [0.074]
Fixed effects:					
Country, industry, year		Y	Y	Y	Y
Country*year		Y	Y	Y	Y
Industry*year		N	N	Y	Y
Reg impact equality test (p-values)			0.2037		0.0029
Observations		2633	2633	2633	2633
R-squared		0.57	0.57	0.648	0.649
RMSE		0.183	0.183	0.1731	0.1729

See footnote to Table 3.

Table B4.2 Differences in upstream regulation impacts on ICT capital intensity between R&D and non-R&D investing industries

Dependent variable: ICT capital intensity		(1)	(2)	(3)	(4)
ICT capital costs		-0.846*** [0.040]	-0.839*** [0.040]	-0.811*** [0.045]	-0.819*** [0.045]
Regulatory burden indicator$_{-1}$	**All industries**	-0.399*** [0.122]		-0.640*** [0.161]	
	R&D industries		-0.374*** [0.124]		-0.669*** [0.162]
	no-R&D industries		-0.489*** [0.149]		-0.455** [0.204]
Fixed effects:					
Country, industry, year		Y	Y	Y	Y
Country*year		Y	Y	Y	Y
Industry*year		N	N	Y	Y
Reg impact equality test (p-values)			0.1253		0.0866
Observations		2633	2633	2633	2633
R-squared		0.867	0.867	0.872	0.872
RMSE		0.4088	0.4088	0.4191	0.419

See footnote to Table 3.

(5). Differences in the impacts of barriers to entrepreneurship and state control

As explained in Appendix A.1 the OECD non-manufacturing regulation indicators can be viewed as the sum of two sub-indicators corresponding to two main types of regulations: for the first, barriers to entrepreneurship and state control that take into account legal barriers to entry, market structures and industry structure, and for the second information on public ownership of leader firms and on public control of business activity (mainly price control). This is thus also the case of our regulatory burden indicator REG which we can divide into the corresponding two components. Since the purpose of State control is largely to internalize market externalities or provide public services, it may not lead to an increase in upstream rents, unlike the barriers to entrepreneurship. It thus seems of particular interest, even at our aggregate level of analysis, to do the tests of comparison of the estimated impacts of these two components of REG on multifactor productivity and ICT and R&D capital.

Table B5.1 presents the results of these tests. We can see that the hypothesis of the equality of the impact coefficients of the two upstream regulation components cannot be rejected, even at the 10% level of confidence, in the productivity equation and the ICT demand and for both our upper and lower bound estimates, but that it is on the contrary strongly rejected for the R&D demand equation and both estimates.

Table B5.1: Tests of equality of the coefficients of the regulatory burden components for state control and barriers to entrepreneurship

P-values	Productivity equation		ICT demand		R&D demand	
	(1)	(2)	(3)	(4)	(5)	(6)
Equality test	0.574	0.792	0.122	0.186	0.004	0.010
Fixed effects:						
Country,	Y	Y	Y	Y	Y	Y
Country*year	Y	Y	Y	Y	Y	Y
Industry*year	N	Y	N	Y	N	Y
Observations	2633	2633	1491	1491	2633	2633

Tests based on the DOLS estimates with one lag and one lead

Table B5.2 thus records the estimation results for the R&D demand equation only. It recalls for comparison in columns (1) and (5) our previous upper and lower bound estimates (from Table 5 in the text), the corresponding new estimates with the two REG components in columns (4) and (8), as well as in the intermediate columns the estimates obtained when only one of these two components are included in the equation. We find that both the upper and

lower estimated impacts of the regulatory burden barriers for the entrepreneurship component are negative and statistically significant as previously, and possibly stronger, while for the State control component they are positive and statistically significant. Although these two components appear negatively correlated, these estimates are not statistically different when one of them is included alone in the equation. These results contrasting sharply with the ones for productivity and ICT capital intensity would be worthwhile investigating in their own right with more appropriate and richer data. A possible explanation is that firms' incentives to invest in R&D and innovate would be higher because state control of upstream firms would prevent them from appropriating a large part of downstream innovation rents.

Table B5.2: Impact of direct State control on R&D demand

Dependent variable: **ICT capital intensity**	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D capital costs	-0.630*** [0.129]	-0.525*** [0.129]	-0.575*** [0.128]	-0.518*** [0.129]	-0.625*** [0.136]	-0.527*** [0.136]	-0.582*** [0.135]	-0.523*** [0.136]
Regulatory burden indicator-1	-1.367*** [0.385]				-0.859** [0.426]			
Barriers to entrepreneurship		-0.969** [0.460]	-0.465 [0.419]			-0.536 [0.485]	0.009 [0.447]	
State control		1.868*** [0.708]		1.248* [0.645]		2.114*** [0.741]		1.792*** [0.681]
Fixed effects: **Country, industry, year** **Country*year** **Industry*year**	 Y Y N	 Y Y N	 Y Y N	 Y Y N	 Y Y Y	 Y Y Y	 Y Y Y	 Y Y Y
Observations **R-squared** **RMSE**	1491 0.8 0.6679	1491 0.799 0.6693	1491 0.798 0.6709	1491 0.798 0.6702	1491 0.808 0.6866	1491 0.809 0.6857	1491 0.807 0.6879	1491 0.809 0.6858

See footnote to Table 3.